ISSN 1346-7565 Acta Phytotax. Geobot. 57 (1): 65–73 (2006)

# *Arundinella riparia* subsp. *breviaristata* (Poaceae), a New Rheophytic Grass from Shikoku, Japan.

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A new rheophytic grass, *Arundinella riparia* subsp. *breviaristata* Ibaragi, is described. It is similar to subsp. *riparia* in leaf anatomy, rhizome shape and habitat, but is different in awn length, spikelet length and distribution.

Key words: *Arundinella*, flora, RDB, rheophyte, Shikoku

*Arundinella riparia* Honda is an endangered rheophyte. It is distinguished from its non-rheophytic ally, *A. hirta* (Thunb.) Tanaka by having a geniculate long awn and long elongate rhizomes (Honda 1929, Tateoka 1969). Although *A. riparia* has occasionally been treated as an infraspecific taxon of *A. hirta* (Ohwi 1941, Koyama 1987), the differences in leaf anatomy also support its distinction from *A. hirta* (Kyoda 1988).

*Arundinella riparia* has been reported from the Tokai area (Shizuoka), the Kii Peninsula and Shikoku (Tokushima and Kochi) (Osada 1989, Abe 1990, Environment Agency of Japan 2000, Ohira 2004). Ishii *et al.* (2001), however, have questioned whether the plants from Tokushima are identical to *A. riparia*, because they lack a geniculate long awn.

To determine the taxonomic status of those plants, the leaf anatomy, awn length variation and rhizome shape of the rheophyte from Shikoku and related taxa were investigated. The results indicate that the rheophyte from Shikoku represents a new subspecies, *Arundinella riparia* subsp. *breviaristata*.

## Materials and Methods

Herbarium specimens of *Arundinella hirta* and *A. riparia* deposited in the following herbaria were studied (abbreviations follow Holmgren *et al.* 1990): KYO, MAK, MBK, TI, TKPM, TNS and TUS. They were also used as the basis for the distribution map (Fig. 6).

Awn length was measured on five florets per specimen. Anatomical observations followed Kyoda's (1988) method. The source of the leaf samples of *Arundinella hirta* and both subspecies of *A. riparia* are listed in Table 1. The samples were fixed in FAA, dehydrated in a tertiary butanol series, sectioned at a thickness of 10 - 12 μm, and stained with Delafield's hematoxylin, safranin, and fast green. For the measurements, ten spikelets were chosen from each specimen examined. The vouchers are deposited in TKPM.

## Results and Discussion

### *Awn length*

Awn length has been regarded as an important diag-

TABLE 1. Vouchers of leaf materials. All specimens are deposited in the Herbarium of Tokushima Prefectural Museum (TKPM).

| Taxa | Locality | Collector | Specimen number or Date |
|---|---|---|---|
| *Arundinella riparia* subsp. *breviaristata* | | | |
| | Tokushima: At the side of Lake Ikeda, Ikeda-cho, Miyoshi-gun. | *Y. Ibaragi* | *111003001, 111003002, 111003003* |
| | Tokushima: Along the Yoshino river, Yamashiro-cho, Miyoshi-gun. | *Y. Ibaragi* | *111003004, 111003005, 111003006* |
| | Tokushima: Yoshino river, Minawa, Ikeda-cho, Miyoshi-gun. | *T. Inobe* | *s.n.* [30 Sep. 1973] |
| *A. riparia* subsp. *riparia* | | | |
| | Mie: Ogawaguchi, Kiwa-cho, Minamimuro-gun. | *M. Ogawa* | *07631, 07635* |
| | Mie: Ogawaguchi, Kiwa-cho, Minamimuro-gun. | *Y. Ibaragi* | *041004001* |
| *A. hirta* | | | |
| | Fukushima: Matsukawa-ura, Soma city. | *T. Kurosawa* | *20234* |
| | Yamanashi: Motosu-lake. | *Y. Akasawa* | *62-J-145* |
| | Tokushima: Orono-dani, Youze, Kamiyama-cho, Myozai-gun. | *Y. Ibaragi* | *161003001* |
| | Tokushima: Takatoi, Sanagouchi-son, Myoudou-gun. | *Y. Ibaragi* | *021003003* |
| | Tokushima: Near the Tokuenji temple, Sanagouchi-son, Myoudou-gun. | *Y. Ibaragi* | *021003005* |
| | Tokushima: Near the hyotanike-pond, Mt. Kajigamie Anan city. | *Y. Ibaragi* | *2809010* |
| | Tokushima: Mt. Tohnomru, Higashiiyayama-son, Miyoshi-gun. | *Y. Ibaragi* | *280903004* |
| | Tokushima: Ohsima Isl., Mugi-cho, Kaifu-gun. | *Y. Ibaragi* | *22100370* |
| | Tokushima: Mt. Atago, Kaifu-cho, Kaifu-gun. | *Y. Ibaragi et al.* | *221003027* |
| | Tokushima: Awanoura, Kainan-cho, Kaifu-gun. | *Y. Ibaragi et al.* | *221003028* |

nostic character in Japanese *Arundinella* (Ohwi 1941, Tateoka 1969). Tateoka (1969) investigated the variation in awn length in *Arundinella* and showed that *A. riparia* has a long, geniculate awn, while *A. hirta* has merely a short projection at the apex of the lemma. Tateoka (1969) reported the variation in awn length in *A. riparia* and *A. hirta* to be 2 - 3.6 mm and 0 - 1.4 mm, respectively.

Fig. 1 shows the variation in awn length in both subspecies of *Arundinella riparia*. The range of variation in awn length of *A. riparia*, 0.1 - 4 mm, is wider than that reported by Tateoka (1969). Because the range of variation in *A. riparia* includes the range of variation of *A. hirta* (Tateoka 1969), it is impossible to distinguish these taxa by awn length alone. The awn of subsp. *breviaristata* is shorter than that of subsp. *riparia* (Fig. 1), as pointed by Ishii *et al.* (2001).

### *Rhizome*

The form of the rhizome has been recognized as one of the important characters for distinguishing the rheophytic *Arundinella riparia* from its non-rheophytic ally, *A. hirta* (Tateoka 1969, Kyoda 1988). The difference in rhizome form is believed to be due to adaptation to habitat. The rhizome of *A. hirta* is always conspicuously horizontally elongated, while that of *A. riparia* usually is not (Fig. 2). Fig. 2-A shows the rhizome of *A. riparia* subsp. *breviaristata*. The rhizome is not horizontally elongated and the buds at the base of the culm elongate upward. These characteristics of the rhizome of *A. riparia* subsp. *riparia* (Fig. 2B) easily distinguish it from *A. hirta* (Fig. 2C).

### *Leaf anatomy*

Kyoda (1988) showed that *Arundinella hirta* has

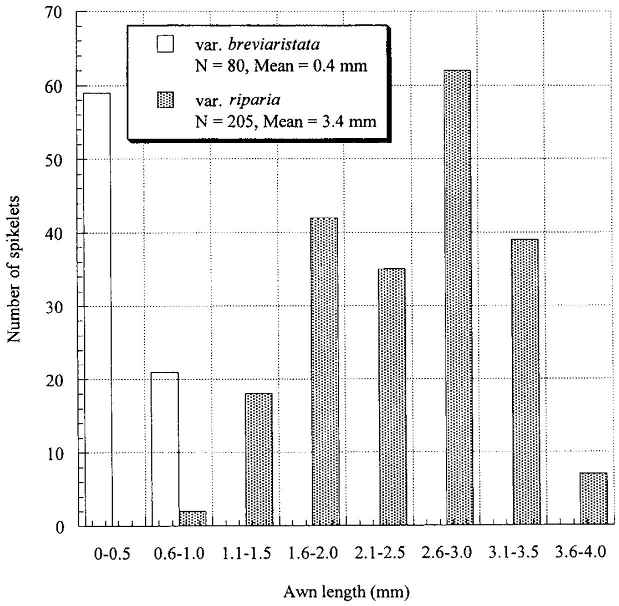

FIG. 1. Distribution and frequency of awn length in *Arundinella riparia.*

large circular cell layers between the Kranz sheath and upper epidermis (Fig. 3C) and that *A. riparia* does not have well-developed large circular cells. Kyoda (1988) examined five samples of *A. riparia* (as *A. hirta* var. *riparia*) including a sample from Shikoku (Kochi Pref. *C. Oda 81118*). Fig. 3A shows the cross section of a leaf of subsp. *breviaristata.* The anatomical features are very similar to those of subsp. *riparia* (Fig. 3B), although subsp. *breviaristata* sometimes has smaller circular cells. *Arundinella riparia* subsp. *breviaristata* is obviously different from *A. hirta* and very similar to *A. riparia* subsp. *riparia* in the anatomical characteristics of the leaf.

The number of sclerenchymatous cells of the leaf margin was not significantly different between the three taxa (Fig. 3D-F).

*Spikelet length*

The spikelet length of *Arundinella riparia* has been reported to show wide variation as follows: 5 - 6 mm (Honda 1929), 4 - 5.5 mm (Osada 1989), 3 - 3.5 mm (Koyama 1980), and 3.5 - 4.5 mm (Environment Agency of Japan 2000). In this research, I examined specimens of *A. riparia* subsp. *riparia* in the major herbaria in Japan from throughout its entire distribution area. I did not find a specimen with a spikelet as small as those reported by Koyama (1980), however. Because it is likely that the measurements include not only those of subsp. *riparia*, but also subsp. *breviaristata*, I did not use the data from Osada (1987) or the Environment Agency of Japan (2000) for comparison in this study.

Fig. 4 shows spikelet length variation in both subspecies of *Arundinella riparia*. The spikelet length in subsp. *riparia* ranges from 4.5 - 5 mm, with a mean of 4.7 mm (n = 40), while subsp. *breviaristata* ranges from 3.2 - 4.2 mm, with a mean of 3.6 mm (n = 120). The spikelets of subsp. *breviaristata* are distinctively shorter than those in subsp. *riparia* (t-test, $P<0.0001$).

*Habitat and distribution*

Both subspecies of *Arundinella riparia* are rheophytic and grow in clusters on rocky river banks that are commonly inundated after flash floods following heavy rains (Fig. 5).

The distribution of the two subspecies of *Arundinella riparia* differs (Fig. 6); subsp. *riparia* occurs on the Kii Peninsula, Shizuoka Prefecture, Honshu, and on part of Shikoku, while subsp. *breviaristata* is restricted to Shikoku.

## Conclusion

Because the anatomical features of the leaf and the shape of the rhizome obviously differ from *Arundinella hirta*, subsp. *breviaristata* is best treated a subspecies of *A. hirta*. *Arundinella riparia* is therefore a species composed of two subspecies, subsp. *riparia* and subsp. *breviaristata.* Both taxa are remarkably similar, but differ in awn length, spikelet length and distribution.

## Taxonomy

**Arundinella riparia** Honda in Bot. Mag. (Tokyo)

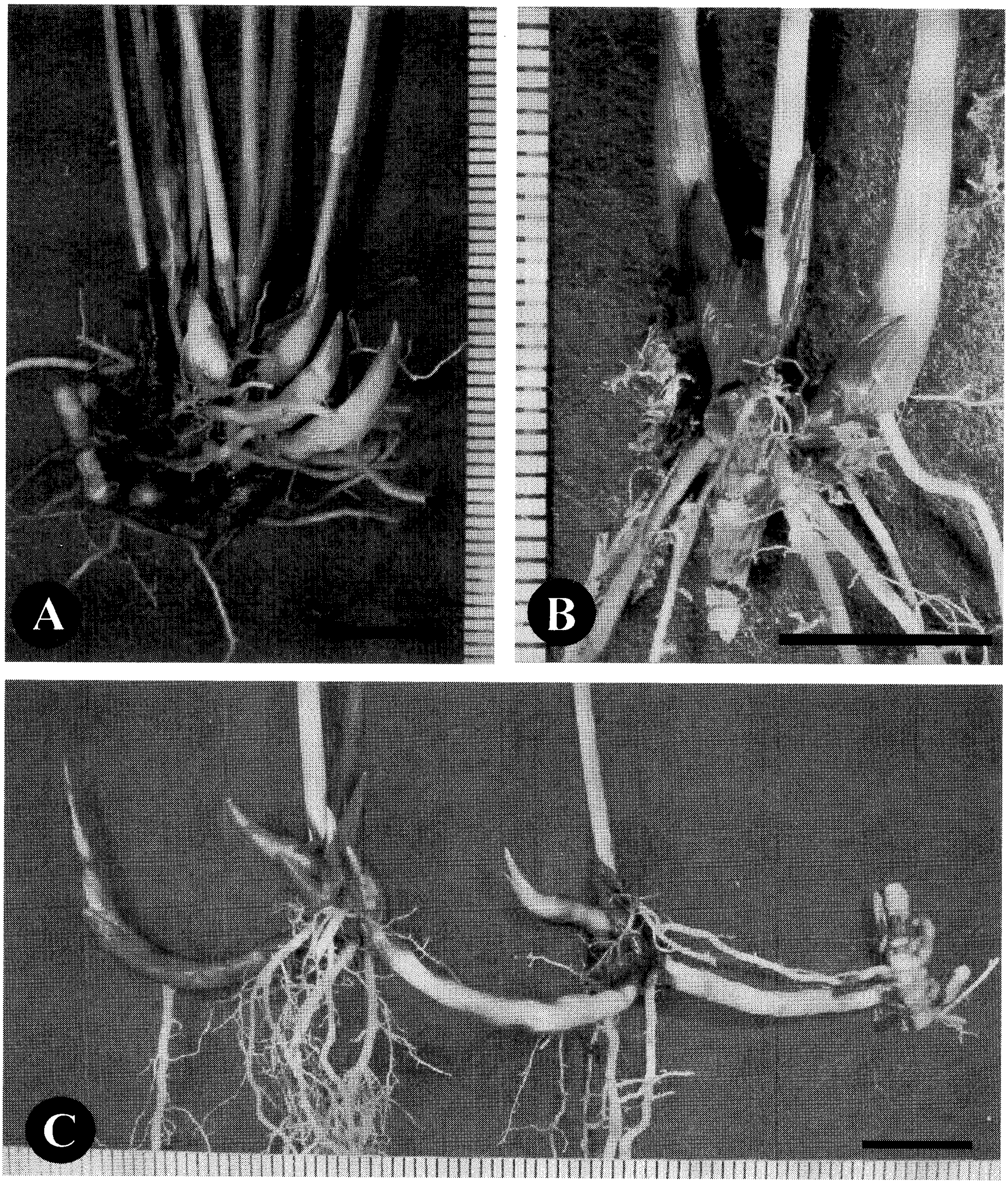

FIG. 2. Rhizome of *Arundinella riparia* and *A. hirta*. A: *A. riparia* subsp. *breviaristata* (*Y. Ibaragi 111003005*, TKPM). B: *A. riparia* subsp. *riparia* (*Y. Ibaragi 041004001*, TKPM). C: *A. hirta* (*Y. Ibaragi 161003001*, TKPM). Bar = 1cm.

43: 192 (1929); Honda in J. Fac. Sci. Univ. Tokyo, Sect. 3 Bot. 3: 310 (1930); Osada, Ill. Grass. Japan: 662 (1989). *Arundinella hirta* var. *riparia* (Honda) Ohwi in Acta Phytotax. Geobot. 10: 271 (1941). *Arundinella hirta* subsp. *riparia* (Honda) T. Koyama, Grasses Japan: 488 (1987). *Syntypes*: NARA. Yoshino-gun. Se, Totukawa-mura, *M. Honda s. n.* [19 Aug 1928] (TI); WAKAYAMA.

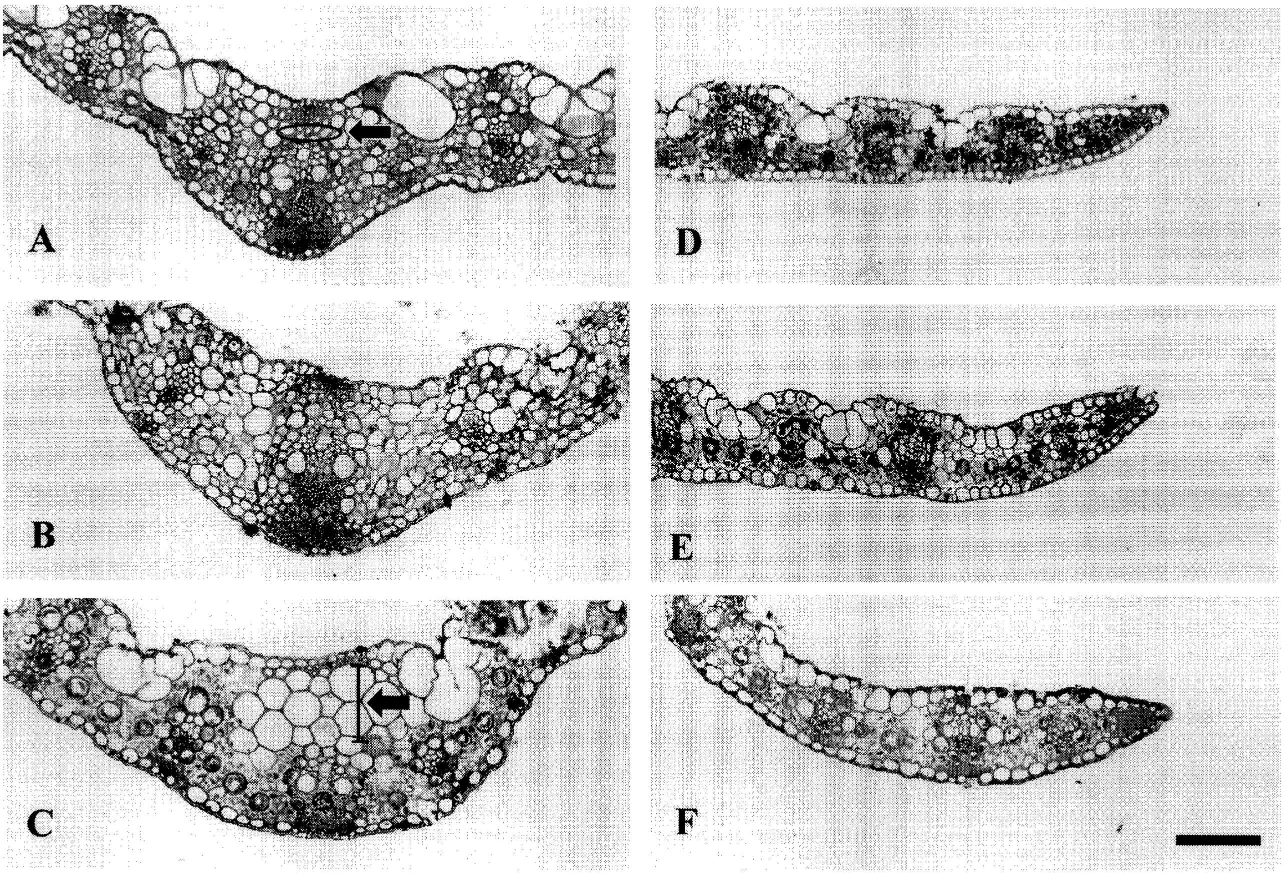

FIG. 3. A-C. Transverse sections at the broadest portion of leaf. A; *Arundinella riparia* subsp. *breviaristata* (*T. Inobe s. n.* 30 Sep 1973, TKPM). B; *A. riparia* subsp. *riparia* (*M. Ogawa 07631*, TKPM). C, F; *A. hirta* (*Y. Ibaragi 161003001*, TKPM). D-F. Transverse sections showing the edge of the leaves. D; subsp. *breviaristata* (*Y. Ibaragi 111003004*, TKPM). E; subsp. *riparia* (*Y. Ibaragi 041004001*, TKPM). arrow; circular cell.

Doro, *N. Ui 2* (TI).

Rhizomes usually not elongate horizontally, with scales. Culms 9 - 62 cm tall, tufted, Leaves basal and cauline; blade 0.5 - 43 cm long, 2 - 10 mm wide, linear, herbaceous, whitish green, margins scabrous and long pilose, apex gradually acuminate; ligule ca. 0.5 mm long, membranaceous, margins ciliate or dentate, truncate; leaf sheath open, glabrous. Panicle 1.5 - 24 cm long, exserted, erect or somewhat inclined apically, lanceolate to linear in outline, loose; inflorescence axis scabrous on angles at least above middle; branches scabrous, suberect to spreading, bearing spikelets from base; pedicels scabrous. Spikelets 3.2 - 5 mm long, 2-flowered; glumes equal in shape, narrowly ovate to lanceolate,

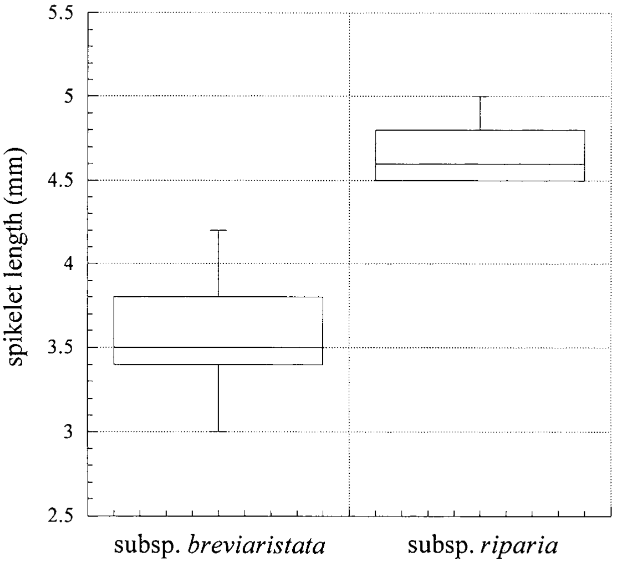

FIG. 4. Variation range of spikelet length in subspecies of *Arundinella riparia*.

## Key to the Subspecies

Spikelets 4.5-5 mm long; awn of lemma 0.9-4 mm long, geniculate or not ················ subsp. *riparia*
Spikelets 3.2-4.2 mm long; awn of lemma absent or to 1 mm long, not geniculate··· subsp. *breviaristata*

apex acute or acuminate, chartaceous, glabrous, smooth; lower glume 2.5 - 5 mm long, nerves 3 or 5, midnerve scabrous; upper glume 3.4 - 4.7 mm long, nerves 5; sterile lemma 3.5 - 4.3 mm long, nerves 3 or 5, chartaceous; sterile palea slightly shorter than sterile lemma, keel smooth or scabrous, thinly chartaceous; anthers 3, 1 mm long, light or dark brown; fertile lemma 2.6 - 3.3 mm long, nerves 3, lanceolate, chartaceous or coriaceous, glabrous, apex acute or acuminate, awnless or awn to 4 mm long; awn scabrous, straight or geniculate; callus densely pilose; fertile palea 2.6 - 3 mm long, lanceolate; anthers 3, 1 mm long, light or dark brown; lodicules 2, transparent; caryopsis 1.3 - 1.7 mm long, ellipsoid, light or dark brown.

subsp. **riparia**, Figs. 2B, 3B & E, 6.
Culms 53 - 62 cm tall. Leaf blades 7 - 43 cm long, 2 - 10 mm wide, glabrous or sparsely pilose with long soft hairs on both surfaces. Panicle 10 - 24 cm long, Spikelets 4.5 - 5 mm long; glumes lanceolate, apex acuminate, chartaceous, glabrous, smooth; lower glume 3 - 5 mm long, nerves 5; upper glume 3.5 - 4.7 mm long, nerves 5; sterile lemma 3.5 - 4.3 mm long, nerves 3 or 5; sterile palea slightly shorter than sterile lemma, smooth or keel scabrous; fertile lemma 2.6 - 3.3 mm long, nerves 3, chartaceous, glabrous, apex acuminate; awn 0.9 - 4 mm long, scabrous, geniculate or not; fertile palea 2.6 - 3 mm long; caryopsis ca. 1.7 mm long, light brown.

*Japanese name*: Migiwa-todashiba, Migiwagaya

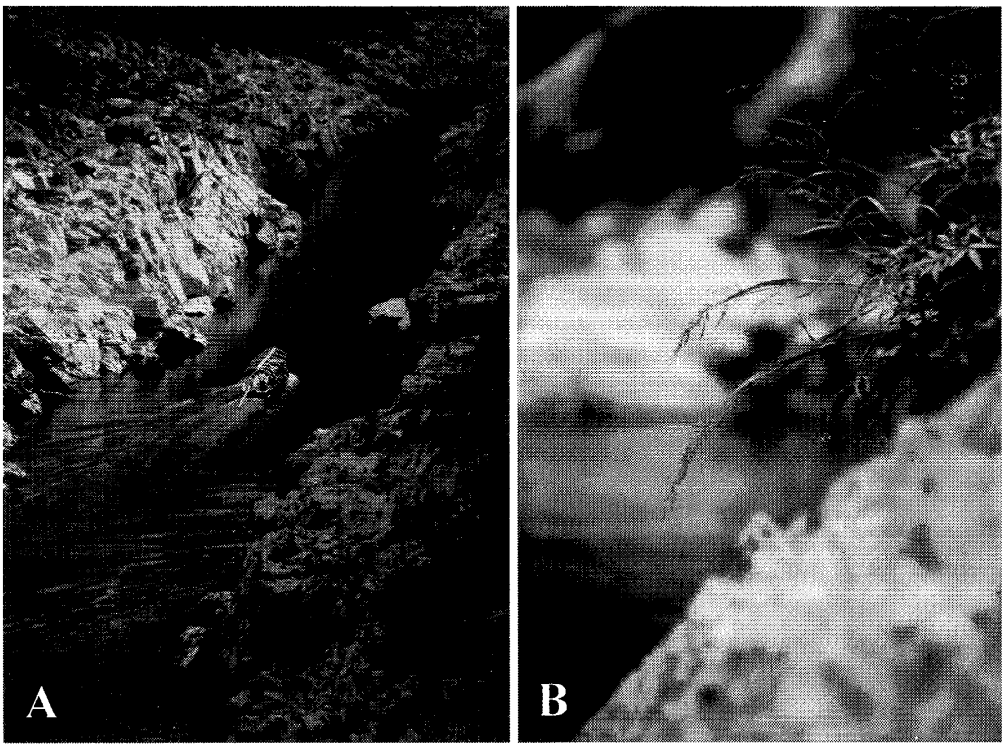

FIG. 5. Habitat and habit of *Arundinella riparia* subsp. *breviaristata*. A: Habitat (Oct. 13, 1999, Ohboke, Yamashiro-cho, Miyoshi-gun, Tokushima Pref. Japan). B: Habit (Oct. 11, 2003, Ohboke, Yamashiro-cho, Miyoshi-gun, Tokushima Pref. Japan).

*Distribution*: Japan (Honshu & Shikoku).

*Specimens examined*: **SHIZUOKA.** Tenryu-shi. Near Kashima bridge, Kashima, Futamata-machi, *J. Sugimoto s. n.* [19 Aug 1953] (TNS). **MIE.** Kumano-shi. Ohidani, Isato-cho, *T. Koide s. n.* [18 Aug 1932] (KYO). Minamimuro-gun. *Nakajima s. n.* [11 Aug 1931] (TI); Kamikawa-mura, *M. Honda s. n.* [23 Nov. 1952] (TI); Kizuro, Kiwa-cho, *Nakai 5465* (KYO); Kizuro, Kiwa-cho, *T. &. F. Yamazaki 1359* (TI); Mt. Tamaoki - Dorohaccho, Kiwa-cho, *G. Koidzumi s. n.* [28-29 Jul 1921] (KYO); Nunobiki waterfall, Funada, Kihou-cho, *G. Nakai 5565* (KYO); Nunobiki waterfall, Funada Kihou-cho, *T. Koide 582* (KYO); Nunobiki waterfall, Funada, Kihou-cho, *Z. Tashiro s. n.* [06 Aug 1933] (KYO); Ogawaguchi, Kiwa-cho, *M. Ogawa 07631* (TKPM); Ogawaguchi, Kiwa-cho, *M. Ogawa 07632* (TKPM); Ogawaguchi, Kiwa-cho, *M Ogawa 07634* (TKPM); Ogawaguchi, Kiwa-cho, *M. Ogawa 07635* (TKPM); Doro kyou, Kiwa-cho, an open rocky place along the water course of the Kitayamagawa, *K. Tsuchiya 1224* (KYO). Taki-gun. Miyagawa-mura, Shimomate, on rocky bank of the Miyagawa River, *K. Seto 15694* (KYO). **NARA.** Shimokitayama-mura, Ikenogo river, *T. Kodama 9759* (TNS); Toda Totsukawa-mura, *G. Murata & H. Koyama 20171* (TNS); Totsukawa river, *J. Sugimoto s. n.* [8 Aug 1966] (TNS). **WAKAYAMA.** Along the Kumano river, *T. Shimizu 77166* (KYO); Higashimuro-gun. Doro, *T. Makino s. n.* [Sep 1924] (MAK); Doro, *collector unknown 5* (MAK); Doro, *Z. Tashiro s. n.* [25 Aug 1928] (TNS); Doro, *S. Suzuki s. n.* [7 Aug 1935] (TNS); Doro, *Y. Goshima s. n.* [Aug 1927] (TI); Doro, *collector unknown s. n.* [02 Aug 1940] (TI); Doro, *T. Makino s. n.* [1922] (MAK); Doro, Kumano river, *S. Sakaguchi 38* (MAK); Dorohaccho, *K. Inagaki s. n.* [date unknown] (TI); Dorohaccho, *collector unknown s. n.* [26 Aug 1925] (MAK); Miyai - Yunomine, Kumanogawa-cho, *G. Koidzumi s. n.* [Jul 30. 1922] (KYO); Tanago dani Kumanogawa-cho, *G. Murata 33744* (KYO). Shingu-shi. *S. Suzuki s. n.* [29 Sep 1929] (TNS); *Y. Satake & S. Okuyama s. n.* [11 Oct. 1942] (TNS); *T. Makino s. n.* [Sep 1924] (MAK); Mt. Kamikura, *S. Suzuki s. n.* [12 Aug 1935] (TNS); Shingu *N. Ui s. n.* [29 Sep 1929] (TUS); Tanago-dani, alt. 200-400m, *G. Murata 33744* (TNS). Tanabe-shi. *T. Makino s. n.* [1931] (MAK). **KOCHI.** Nanogawa-mura, *C. Oda 81118* (TNS). **Cultivated.** Nishinomiya-shi. Cultivated, *T. Makino s. n.* [Oct 1936] (MAK).

subsp. **breviaristata** Ibaragi., **subsp. nov.,** Figs. 2A, 3A&D, 4, 5, 6, 7.

*Arundinella hirta* var. *riparia*. auct. non (Honda) Ohwi: Abe, Tokushima Ken Shokubutu Shi: 266 (1990).

A typo aristis spiculae brevissimis diversa.

*Typus*: Japan, Tokushima Pref., along the Yoshino River, Yamashiro-cho, Miyoshi-gun, 11

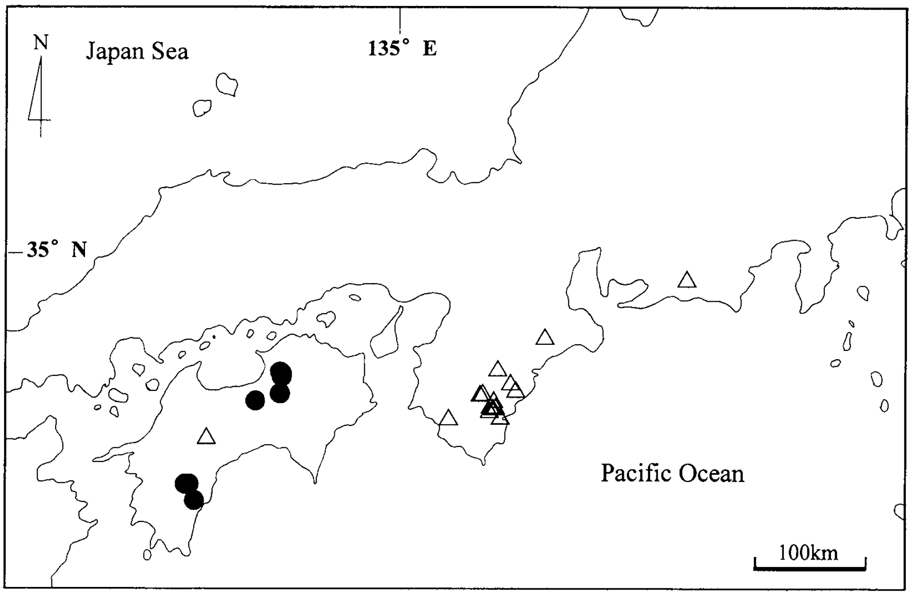

FIG. 6. Distribution map of *Arundinella riparia* subsp. *riparia* (△) and subsp. *breviaristata* (●).

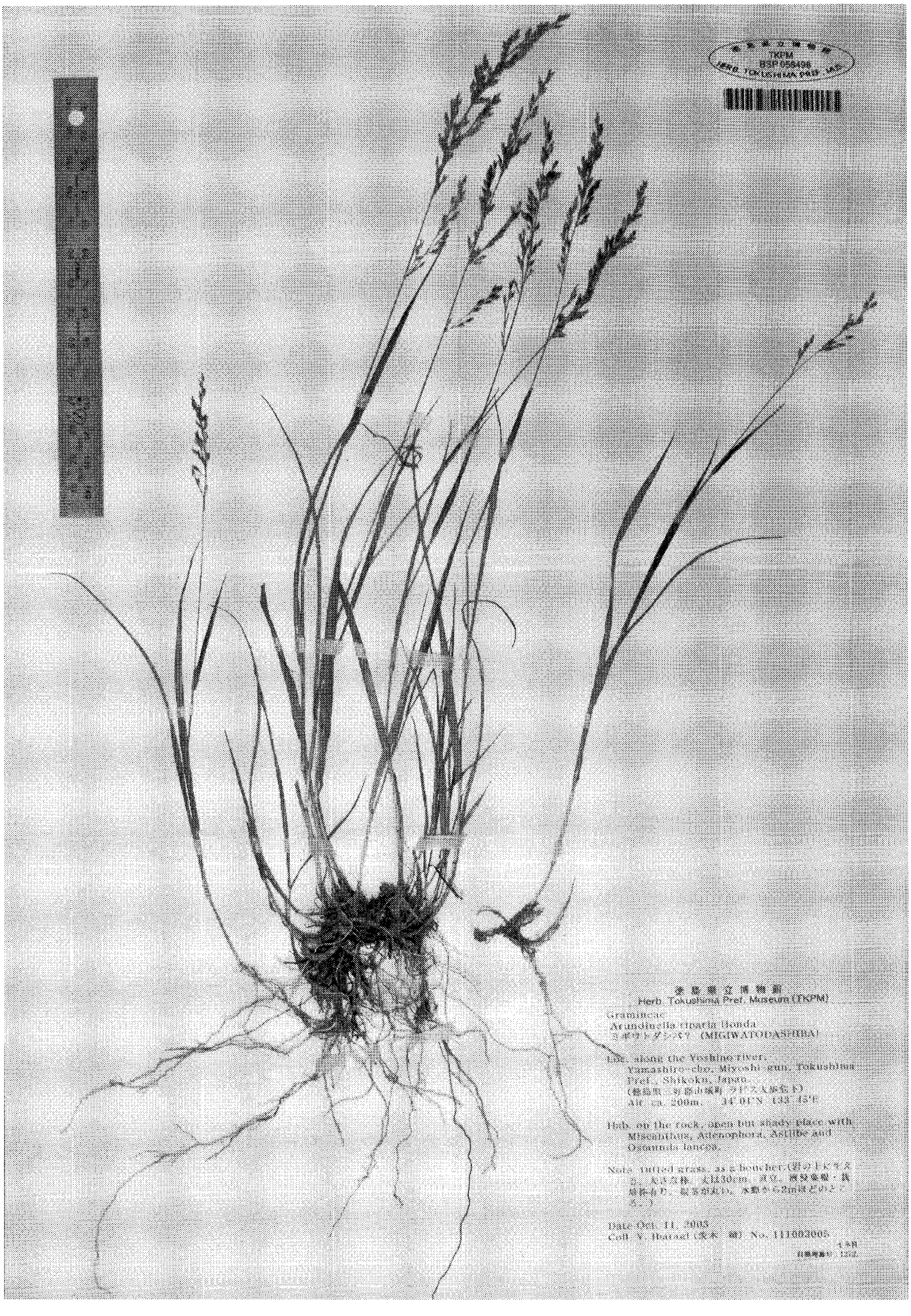
TKPM
Herb. Tokushima Pref. Museum (TKPM)
Gramineae
Arundinella riparia Honda
(MIGIWATODASHIBA)
Loc. along the Yoshino river,
Yamashiro-cho, Miyoshi-gun, Tokushima
Pref., Shikoku, Japan.
Hab. on the rock, open but shady place with
Miscanthus, Astilbe and
Osmunda lancea.
Date Oct. 11. 2003
No. 111003005

FIG. 7. Holotype of *Arundinella riparia* subsp. *breviaristata* (*Y. Ibaragi 111003005*, TKPM)

Oct 2003, *Y. Ibaragi 111003005* (holotype- TKPM)

Culms 9-57 cm tall. Leaf blades 0.5-18 cm long, 3-7.5 mm wide, sparsely pilose with long hairs on both surfaces. Panicle 1.5-22 cm long; Spikelets 3.2-4.2 mm long; glumes narrowly ovate, apex acute or acuminate, chartaceous, glabrous, smooth, with pronounced nerves; lower glume 2.5-3.3 mm long, nerves 3 or 5; upper glume 3.4-3.7 mm long, nerves 5; sterile lemma 3.5-3.6 mm long, nerves 3 or 5; sterile palea nearly equaling sterile lemma, keel scabrous; fertile lemma 2.6-3 mm long, nerves 3, coriaceous, glabrous, apex acute, awnless or awn to 1 mm long, scabrous; fertile palea 2.6-3 mm long; caryopsis ca.1.3 mm long, dark brown.

*Japanese name*: Ohbokegaya

*Distribution*: Japan (Shikoku).

*Additional specimens examined*: **TOKUSHIMA**. Miyoshi-gun. Along the Yoshino river, Yamashiro-cho, *Y. Ibaragi 111003004* (TKPM); Ohboke, Yamashiro-cho, *T. Tabuchi s. n.* [25 Sep 1997] (TKPM); On the rock of Ohboke valley, Yamashiro-cho, *C. Abe 33341, 33342 , 33343* (TKPM); Ikeda-cho. At the side of Lake Ikeda, *Y. Ibaragi 111003001, 111003002, 111003003* (TKPM); Yoshino river, *S. Takafuji s. n.* [15 Aug 1983] (TKPM); Minawa, Yoshino river, *T. Inobe s. n.* [30 Sep 1973] (TKPM); Nakanishi, Yoshino river, *Y. Ibaragi & M. Ogawa 131001* (TKPM). **KOCHI.** Nagaoka-gun. Sakamoto, *Y. Kohkami et al. FOK-049366* (MBK); Tosashimizu-shi. Masuno river, Ofuji-ga-todoro, *Y. Kohkami 9524* (MBK); Hata-gun. Eshi, Taisho-cho, *N. Kuroiwa et al. FOK-062669* (MBK); Yoshikawa, Taisho-cho, *N. Kuroiwa et al. FOK-062397* (MBK); Saga-cho, *N. Kuroiwa et al. FOK-041263* (MBK).

I would like to thank Dr. K. Kyoda and Dr. H. Ohashi for their valuable suggestions on improving the paper. I wish to express my thanks to Dr. M. Suzuki of Tohoku University, Dr. T. Nemoto of Ishinomaki Senshu University and to Dr. Y. Ohmori of the Yokosuka City Museum for kind advice on methods of anatomical observations. Thanks are due to the curators and staffs of KYO, MAK, MBK, TI, TNS and TUS for providing facilities for study at their institutions. I am also grateful to Mr. S. Kinoshita of Naruto City, Tokushima and Dr. Siro Kobayashi of the Kochi Prefectural Makino Botanical Garden for giving me information about rheophytic *Arundinella* in Tokushima and Kochi prefectures. I am indebted to Mr. D. J. Viery and Mr. M. Keezing for critically reviewing the manuscript. I would like to thank the anonymous reviewers for their valuable suggestions on improving the paper.

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*Received May 12, 2005; accepted January 23, 2006*